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ABSTRACT

The development of information systems in higher education in the United States has paralleled the development of large-scale electronic computers. There are a number of conceptual designs for information systems in higher education. There also exist different information requirements for operation of a university, coordination of educational systems, and establishment of national policies; therefore, the design of information systems must accommodate needs at the operational, coordination, and policy levels. Data requirements and systems requirements are to be viewed from these three perspectives. Certain specific developments in the field may be applied to Brazilian higher education systems. (Author/MSE)

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THE DESIGN AND APPLICATION OF INFORMATION SYSTEMS IN HIGHER EDUCATION

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Introduction

One of the functions of management identified in "The Functions of Management in the University" is communication--the process of exchanging information. Some individuals fail to realize that information is received by management as well as dispensed. For colleges and universities in the United States the communication process is a vital part of their existence. It is for this reason that college and university administrators and managers have taken an active interest in the development of comprehensive information systems.

The development of these information systems have paralleled the development of large-scale electronic computers in the United States. The concept of comprehensive information systems for planning and management in colleges and universities, although in existence for many years, expanded rapidly during the late 1960's and early 1970's. During that time development of information systems was spearheaded by the National Center for Higher Education Management Systems (NCHEMS) at the Western Interstate Commission for Higher Education (WICHE). The program at NCHEMS was developed in response to a need for information and accountability in higher education. The efforts of NCHEMS in the area of planning in management systems in higher education have had a profound impact on the development of information systems and will continue to have an impact in the foreseeable future.

The influence of NCHEMS has been felt not only in the United States but also in several industrialized countries that are participant nations in the Organization for Economic Cooperation and Development (OECD) program on Institutional Management in Higher Education (IMHE). NCHEMS and OECD have undertaken extensive research on the application of planning and management tools to the higher education enterprise.

The purpose of this paper is to provide a general review of some conceptual designs of information systems in higher education and the application of these systems to the planning and management functions in colleges and universities. There are different information requirements for operation of a university, coordination of educational systems, and the establishment of national policies; therefore the design of information systems must take into consideration the different needs at the operational, coordination, and policy levels. The data requirements and information systems requirements are reviewed here from these three perspectives. Finally specific developments in information systems that may be applied to Brazilian higher education systems are discussed.

Information systems for higher education were developed primarily by systems analysts and computer scientists using a language that is foreign to the layman. For this reason definitions used in this paper are given below:

Information System - Information systems are the procedures and channels through which information is systematically exchanged in an organization.

Transactional Information System - Transactional information systems (TIS) provide information on transactions in an organization. This is the lowest level of information obtainable.

Management Information Systems - A management information system (MIS) is the systematic aggregation of transactional and operational information into reports that provide critical information to managers.

Operating (Control) Information System - Operating or control information systems are systems designed to provide middle level managers with information critical to the day-to-day control in an organization. An operating information system differs from a management information system in that it focuses on short-term control in the organization whereas a management information system also considers long-term implications.

Planning, Management, and Evaluation System - A planning, management and evaluation (PME) system combines transactional, management and operating information in a systemmatic manner for use in planning, management and evaluation decision-making.

Higher Education - Higher education refers to universities, colleges, community colleges, and technical institutes; coordinating systems for higher education; and state and national bodies that set policies for these institutions.

Information Systems in Higher Education - An Overview

There are many forms of information systems in higher education, and they vary according to the level at which the user of the information is located. For most publicly supported universities of higher educatio in the United States there are usually four levels of information us the university level, the coordinating agency level, the state level the national level. These four levels are shown in Figure 1, which indicates the aggregation of information normally required at each level. As the level of the information user increases, so does the aggregation of information required.

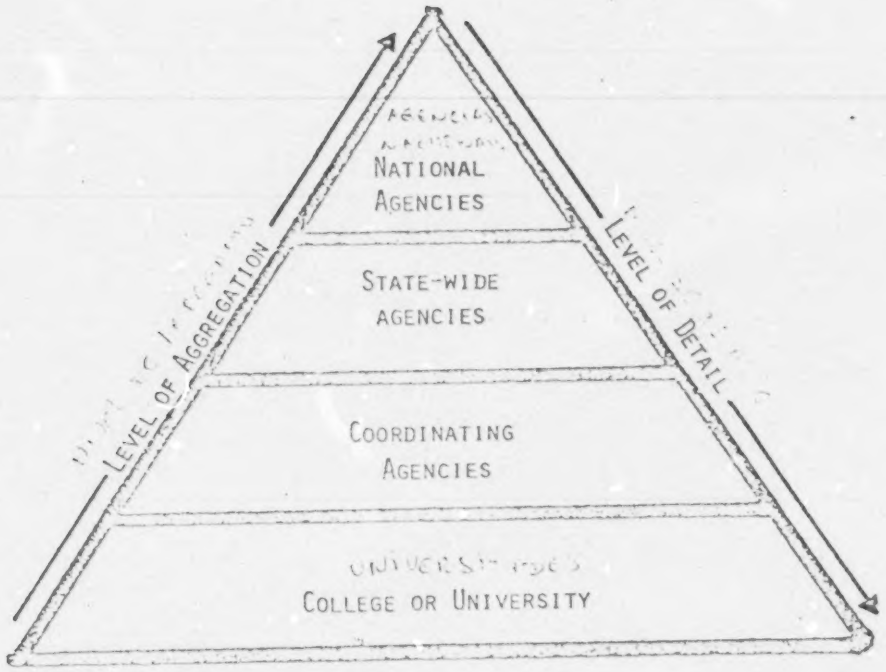


FIGURE 1: LEVELS OF INFORMATION USERS

The four-level approach to policy-making and coordination in higher education is a relatively recent occurance in the United States. Prior to the early nineteen sixties when many states of the United States developed multi-campus systems of higher education, three distinct levels existed in higher education: the operational level, the co-ordinating level, and the policy level.

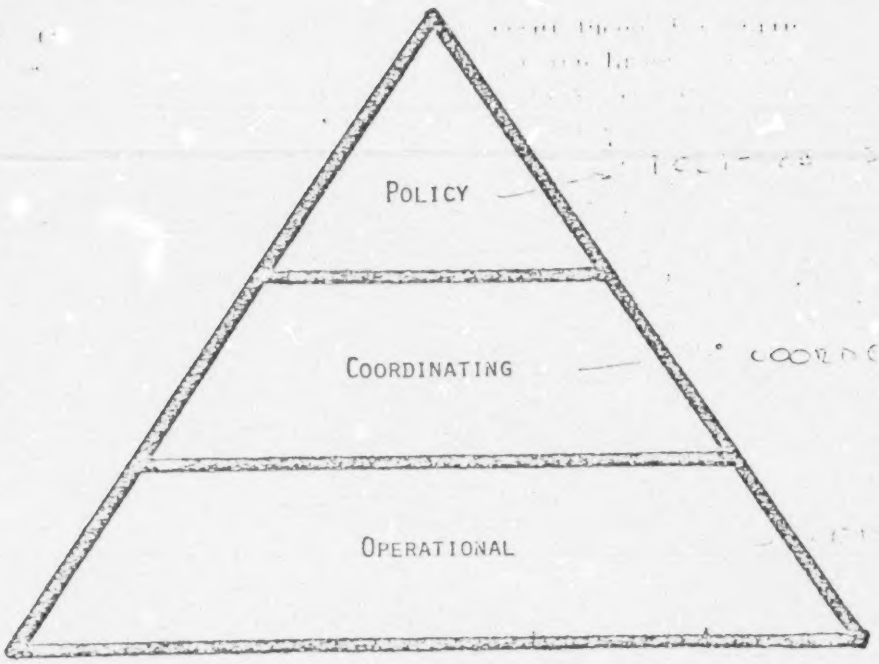


FIGURE 2: LEVELS OF DECISION-MAKING IN THE UNIVERSITY

Figure 2 shows the more conventional three-level approach to higher education organization. Because this approach is still widely utilized internationally, it will be discussed in more detail here.

At the university level, information is required for operational purposes. For this reason, transactional and operational information systems are required to provide information on all aspects of institutional operations. Of particular concern is information on the business, academic and research affairs of the university.

TABLE 1: CAMPUS LEVEL INFORMATION REQUIREMENTS

STUDENT
- APPLICATIONS
- ENROLMENTS
- MAJORS
- SEX AND ETHNIC STATUS
- TUITION AND FEE CHARGES
- ECONOMIC STATUS

FACULTY
- NUMBER OF FACULTY
- PERCENT TENURED
- RANK AND AGE DISTRIBUTION
- SALARIES
- WORKLOADS

PART-TIME
- FULL-TIME RATIO
- AFFIRMATIVE ACTION

FINANCIAL
- CURRENT INCOME/EXPENDITURES
- PROJECTED INCOME/EXPENDITURES
- COSTS PER STUDENT
- COSTS PER CREDIT/COURSE
- FINANCIAL AID

COURSES
- AVERAGE SECTION SIZES
- FREQUENCY OF OFFERINGS
- CURRENT TECHNOLOGY
- CREDIT VALUES

FACILITIES
- UTILIZATION RATES
- MAINTENANCE COSTS
- HEATING/UTILITY COSTS
- ADEQUACY OF SPACE

At the coordinating level, which in this case includes all intermediate levels of coordination, information is needed to support decisions on resource allocations among several institutions rather than within a single college or university. At this level, aggregated information on academic programs is usually most important.

One of the more important decision points for publicly supported institutions in the United States is the state-level coordinating body. At the state level, more aggregate data are required to make decisions concerning resource allocations between higher education and other activities that compete for resources. Since most publicly supported colleges and universities in the United States receive substantial portions of their budgets from state resources, these universities and colleges compete with other demands such as welfare, highway and rapid transit systems, and other publicly funded activities. It is for this reason that administrators in higher education, though somewhat reluctant to provide transactional information to state level planners, are eager to offer convincing evidence in support of the benefits of higher education.

At the national level highly aggregated information is required; therefore, decisions are much broader in scope, reflecting national educational policy concerns. Information required to support policy decisions consist of aggregated data on the number of students enrolled in higher

education, the amount and the kinds of research to be funded, the dollars that are to be spent on research activities, and other issues having broad national significance.

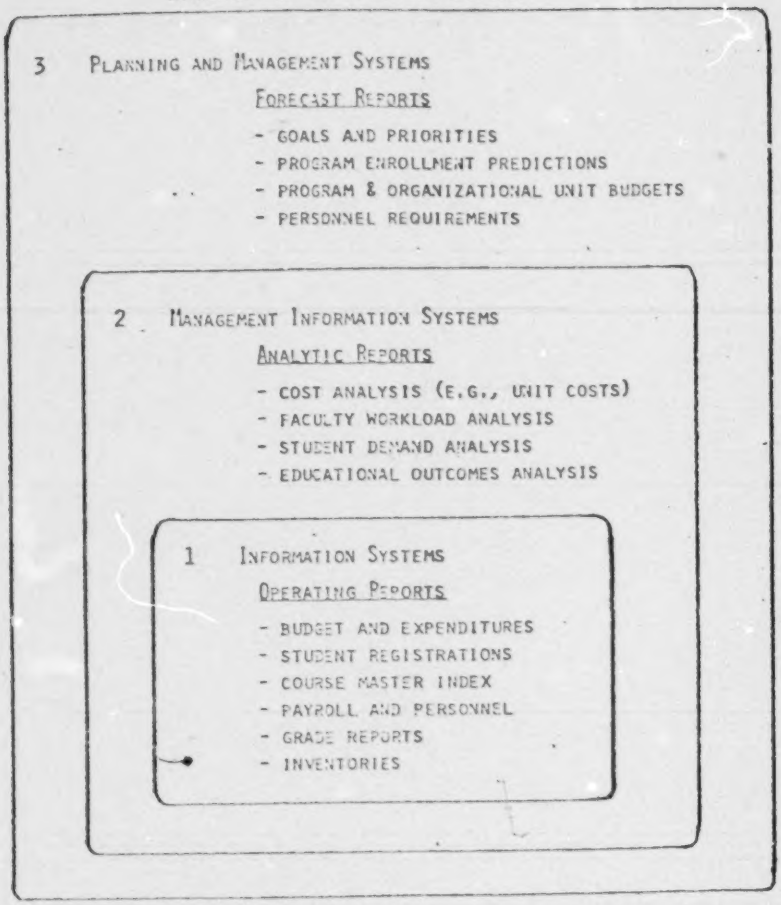
Educational policies designed to achieve national objectives should be formulated by a national administration. These educational policies should reflect objectives of the government and should be designed to accomplish a number of goals. Depending on the needs and priorities of the country, such goals as economic and technological development, improved health care, increased educational attainment, expanded research and development capabilities, and increased agricultural and industrial production may be pursued.

Because educational policies can and often are designed to accomplish a variety of objectives, information must be collected on many facets of a country's activities. It is therefore important to design an information system which not only encompasses the educational system of the country, but other areas where it is desirable to monitor progress towards stated objectives. Thus an information system may take on different characteristics depending on the level for which the system is designed.

Designing an Information System

Most information systems were designed at the operational level and persons at the coordinating and policy levels use information aggregated from this level. Therefore this paper concentrates on characteristics of information systems at the operational level. Figure 3 shows a hierarchy of information within a college or university and examples of information at each level in the hierarchy.

FIGURE 3
HIERARCHY OF INFORMATION SYSTEMS*



*SHEEHAN, BERNARD S., REPORT ONE - WESTERN CANADIAN UNIVERSITIES TASK FORCE ON INFORMATION NEEDS AND SYSTEMS, UNIVERSITY OF CALGARY, ALBERTA, CANADA, NOVEMBER, 1972.

The lowest level of information shown in Figure 3 is operational reports that have been aggregated from transactional information. An information system must be designed to capture necessary data at the transactional level in order to build on the system or to gain useful operating or management information.

An effective transactional information system not only captures data about the business affairs of the university but also obtains data on

the academic affairs and other areas such as alumni affairs, fund-raising, and research. Figure 4 displays how a comprehensive information systems for a college or university can be viewed conceptually. The figure takes a detailed look at the transactional information required to operate an institution and indicates aggregations required for management, coordinating and policy reports. When designing the information system, adequate attention must be given to each aspect of the design.

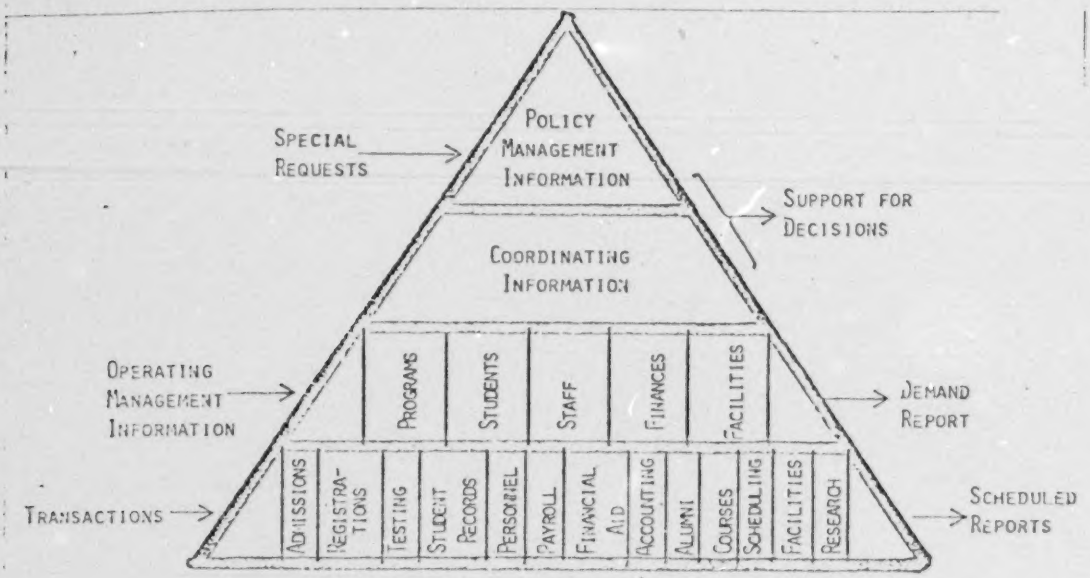


FIGURE 4: CONCEPTUAL DESIGN OF COMPREHENSIVE UNIVERSITY INFORMATION SYSTEM

A major concern of information systems designers should be data definitions and compatability. To assist with this problem in the United States, NCHEMS developed two very important products, the data-element dictionary (DED) and the program classification structure (PCS).

The data-element dictionary defines data elements used in institutions of higher education in the United States. Institutions using the DED can exchange information with confidence that data definitions and procedures are comparable. The availability of a data-element dictionary is of prime importance, not only when data is to be exchanged among institutions, but also when various systems within a university must be designed to interface with each other. For example, the same data element is utilized in several of the transactional areas shown in Figure 4. If a data element were defined differently in each of the transactional areas, then the information system would be too confusing to be of much use to managers.

The program classification structure, also developed at NCHEMS, is a

filing system that allows institutions throughout the United States to compare programs. The core of the PCS is the higher education general information system (HEGIS) taxonomy used to identify academic programs.

Designing an information system is a five phase process. The five phases are:

1. Definition
2. Analysis
3. Design
4. Implementation
5. Maintenance/Improvement

Of primary concern during the definition phase is the purpose of the information system. The purpose, for the most part depends on the level the information system is being designed to serve. During this phase it is important to consider alternative approaches to solve the information flow and availability problem, the scope of the system, and interfaces with external agencies.

In the analysis phase detailed consideration must be given to data availability and requirements, equipment availability, and methods that can be used to solve various problems. It is during this phase that system specification along with methods and techniques should be finalized.

During the design phase itself procedures, system documentation, operating procedures, and user training are the primary activities. Other important considerations in designing an information system are system users and unforeseen applications. Therefore a management information system should, at a minimum:

1. Support executive usage.
2. Cross organizational lines.
3. Serve top management
4. Be responsive to unstructured requests for information.
5. Embody techniques of management science.
6. Provide integrated and non-redundant information.

Information systems designed with the above characteristics will serve management effectively.

System Applications

There are many uses to which information systems could and should be put. However, the ones that stand out are:

1. Management control
2. Planning, management and evaluation
3. External report
4. Information exchange for comparative analyses

Management control is the process by which institutional managers decide whether or not their college or university is meeting its stated objectives. In order to make such decisions, an abundance of information is required on such variables as the enrollment of students in academic programs, the volume and types of research being conducted, the number of research grants and contracts awarded to the institution and the number of degrees awarded.

Another important use for an information system is the planning, management and evaluation processes. Figure 5 depicts the planning management and evaluation cycle at colleges and universities as a feedback system, which, if it is to be operated properly, must receive information on its operations promptly, in order that planning decisions can be made and that prior decisions can be revised if necessary. Also evaluative information is required of the system if the corrective process is to be effective. That is, the actual output of the system must be measured and compared with the expected output.

A Representation of the Planning Cycle

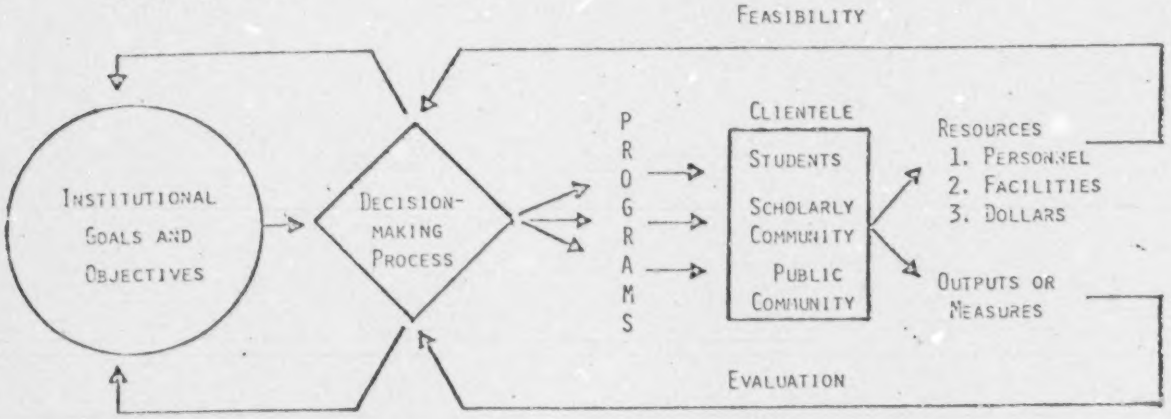


Figure 5: Planning, Management, and Evaluation Cycle in the University

An indispensible part of the planning, management and evaluation cycle is the setting of measurable university goals and objectives. This is shown in Figure 5. Once goals and objectives have been accepted, the management process consists of directing purposeful activities towards the attainment of these goals and activities. This takes place in the diamond-shaped area labeled "Decision-making Process" and the committing of resources to programs for approved activities.

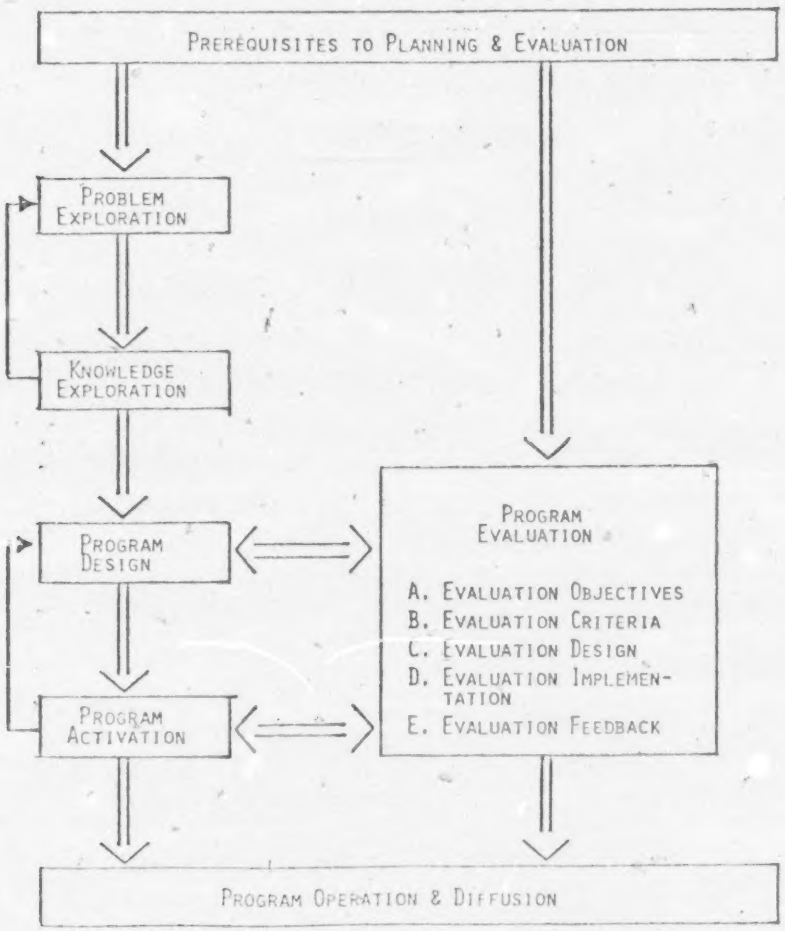
A good information system is required to provide information on resources and on measures of goal attainment. Information provided by the system

can then be used as part of a feedback loop; allowing managers to take corrective actions either during the period of the cycle or prior to the beginning of the next cycle.

A separate view of the phases of planning is depicted in Figure 6. In this figure it is assumed that the prerequisites to planning and evaluation, such as having clearly defined goals, occurs as the very first part of the activity. The Figure also indicates the constant interaction between program evaluation and program design and activation. It is in the critical area of this interaction that an information system must be of assistance. For this reason, when the information system is designed, evaluation criteria A through E must be thoroughly considered.

FIGURE 6: THE PROGRAM PLANNING MODEL

FLOW OF ACTIVITIES BETWEEN PHASES OVER TIME



Another important application of information systems is the reporting function. In higher education both the internal and external reporting functions are considered important. However, because institutions receive large sums of money from external agencies, the external reporting function is considered to be of utmost importance. Colleges and universities are required to report on all facets of operations, and their reports are sent not merely to one agency but to several state, local and national agencies--and in many instances to private professional organizations--seeking information on university operations. Although institutions are not legally required to respond to each of these requests, it is nevertheless considered important that the institution respond when possible.

A final important application of information systems is that of comparative analyses and information exchange among institutions. During the past few years information exchange and comparative analyses have become an important part of the American higher education scene. The United States Congress and state legislatures are, with increasing frequency, demanding comparative information on academic programs at many of the institutions of higher education. Comparative information on costs and other variables is required not only from publicly supported universities but also from private universities that received relatively small amounts of funding from the public treasury.

The impetus for such comparative information has been rapidly rising costs in higher education and the increasing demand from taxpayers for accountability on the part of institutions of higher education. After the period of rapid and almost uncontrolled growth during the 1960's when world-wide inflation eroded the purchasing power of the dollar, institutions of higher education found themselves in difficult financial situations. In order to avoid bankruptcy, many universities had to rely on federal funds. Because of this, the institutions were required to adhere more closely to federal reporting requirements: demonstrating the "golden rule," he who has the gold makes the rule.

Many systems have been developed to assist institutions with the exchange and comparison of data; specifically cost information. The most widely used systems were developed at NCHEMS and have gained widespread acceptance in the academic community in the United States. Fortunately the systems were designed to meet the needs of persons at all levels of higher education which has made a lasting contribution to higher education in the United States.

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Table 1: Campus Level Information Requirements

Student

- Applications
- Enrollments
- Majors
- Sex and Ethnic Status
- Tuition and Fee Charges
- Economic Status

Faculty

- Number of Faculty
- Percent Tenured
- Rank and Age Distribution
- Salaries
- Workloads

Part-Time

- Full-Time Ratio
- Affirmative Action

Financial

- Current Income/Expenditures
- Projected Income/Expenditures
- Costs per Student
- Costs per Credit/Course
- Financial Aid

Courses

- Average Section Sizes
- Frequency of Offerings
- Current Technology
- Credit Values

Facilities

- Utilization Rates
- Maintenance Costs
- Heating/Utility Costs
- Adequacy of Space

A REPRESENTATION OF
THE PLANNING CYCLE

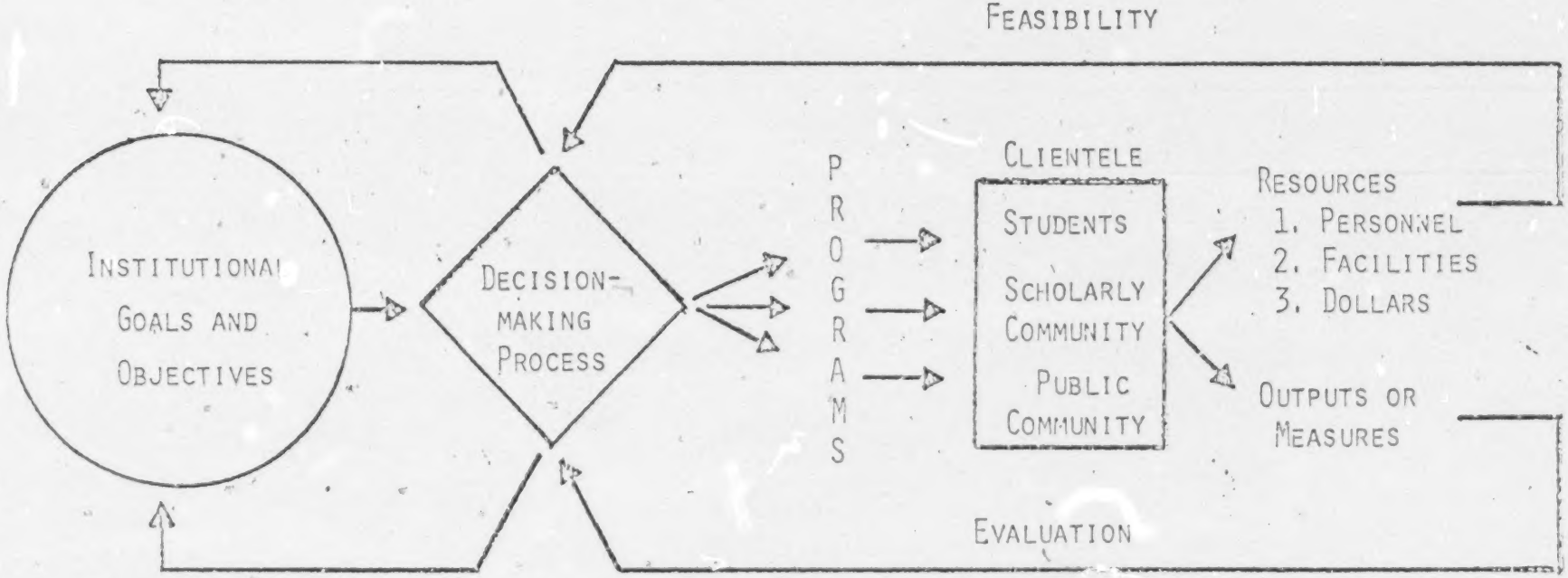


FIGURE 5: PLANNING, MANAGEMENT, AND EVALUATION CYCLE IN THE UNIVERSITY

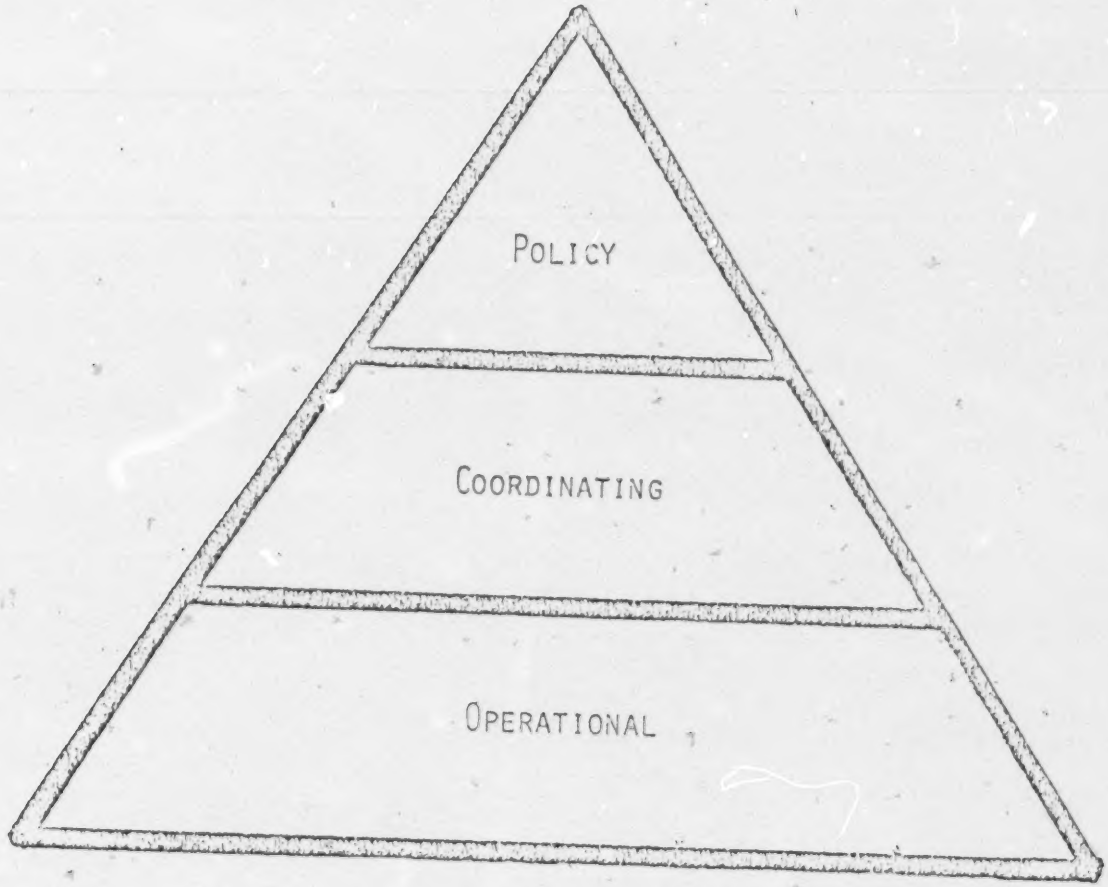


FIGURE 2: LEVELS OF DECISION-MAKING IN THE UNIVERSITY

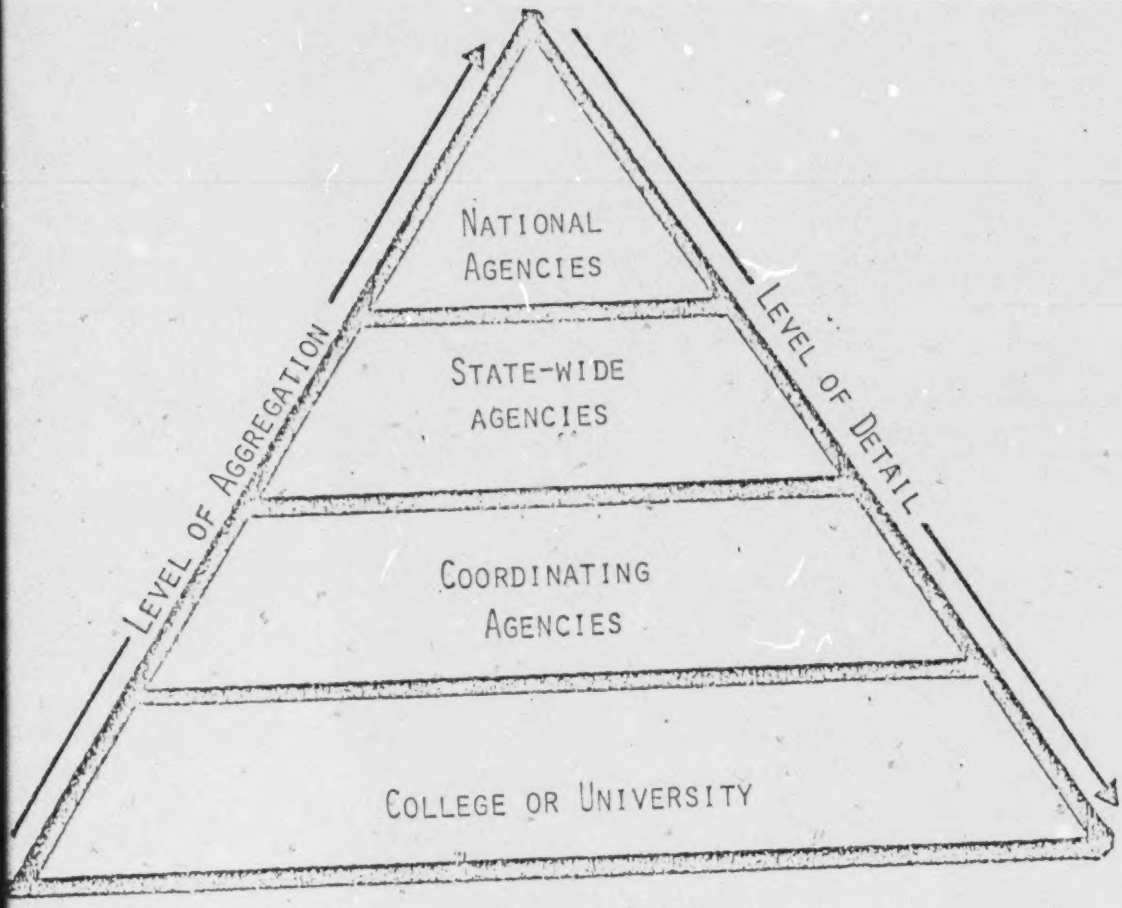


Figure 1: Levels of Information Users

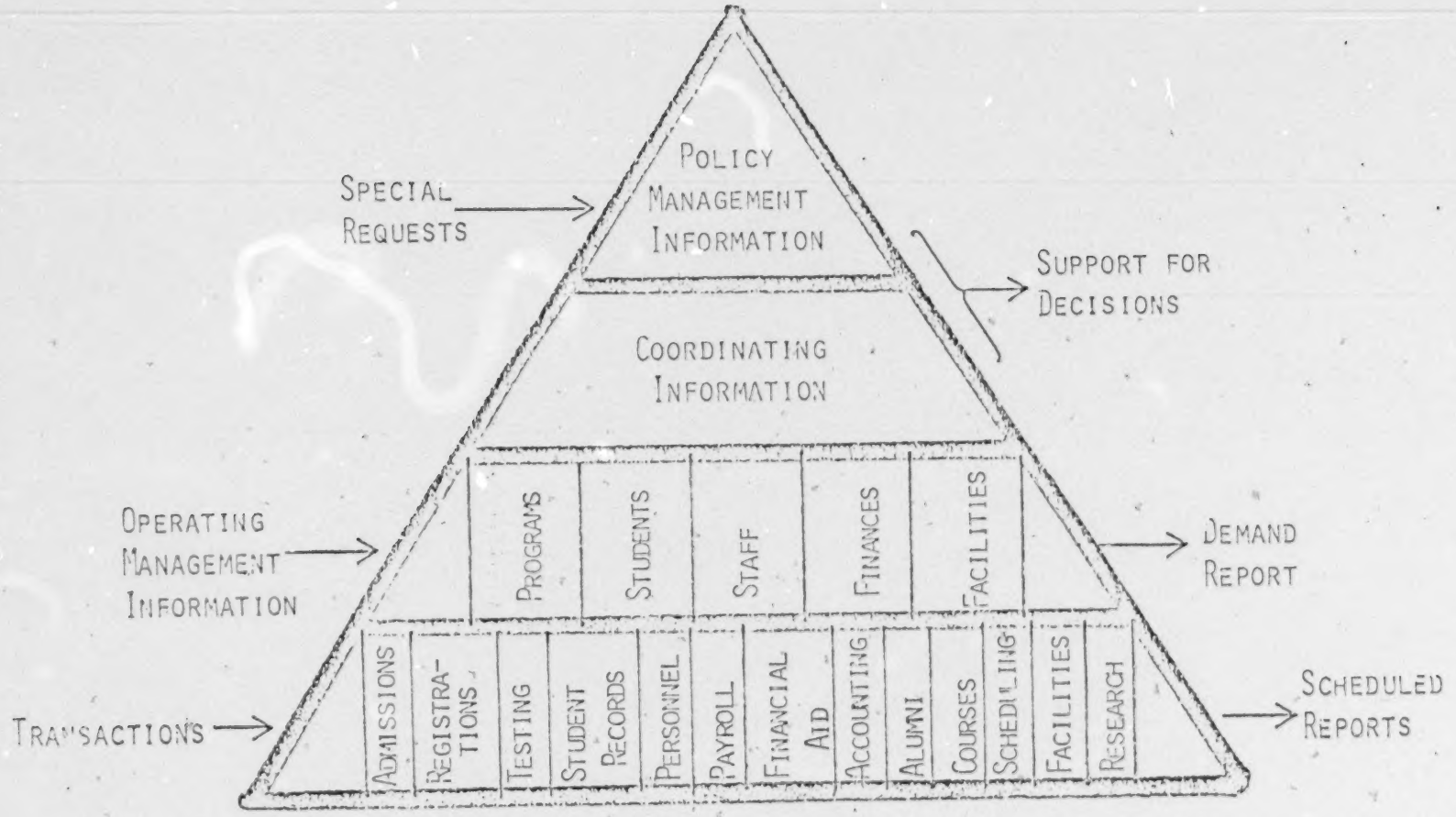


FIGURE 4: CONCEPTUAL DESIGN OF COMPREHENSIVE UNIVERSITY INFORMATION SYSTEM

FIGURE 6: THE PROGRAM PLANNING MODEL

FLOW OF ACTIVITIES BETWEEN PHASES OVER TIME

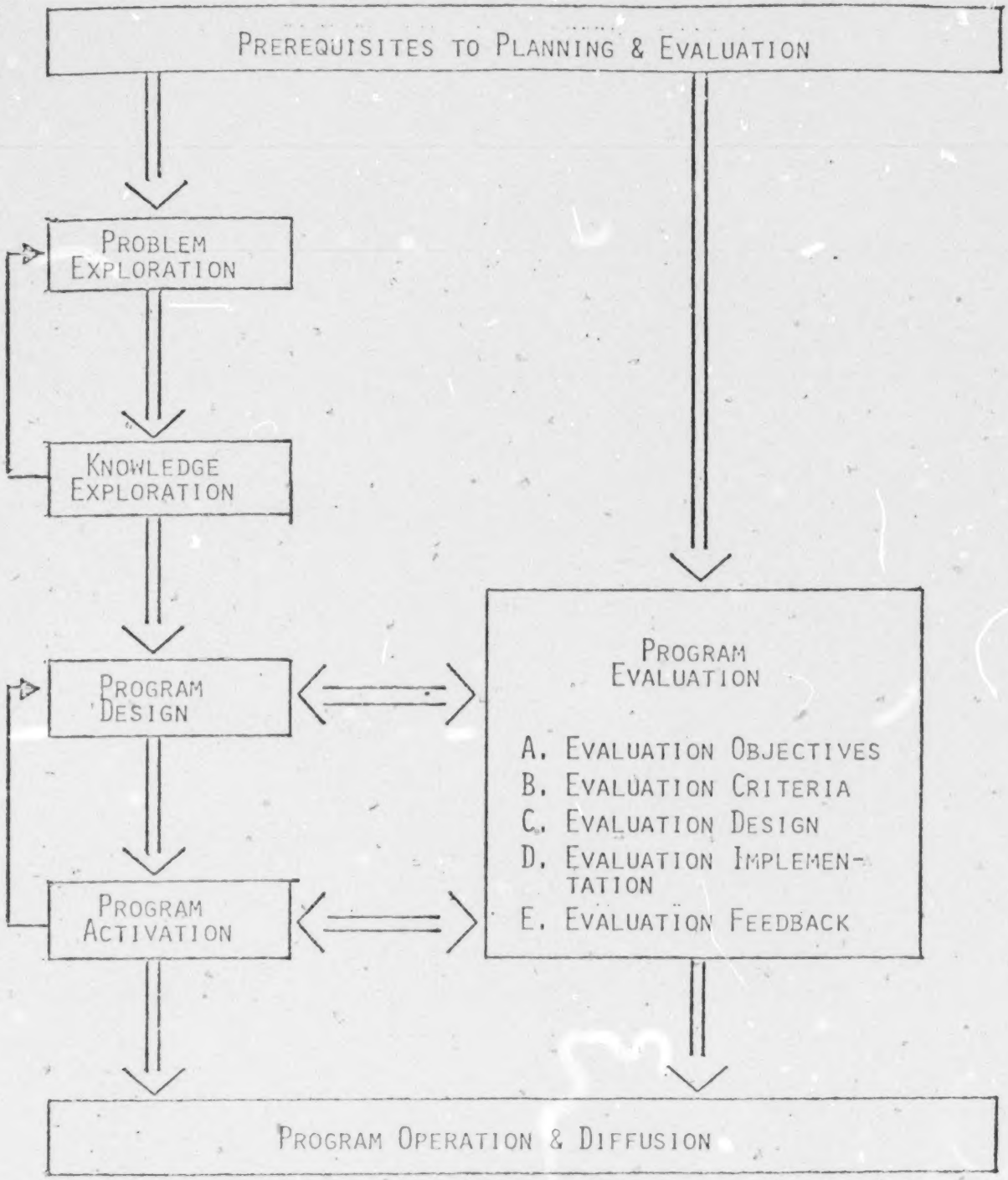
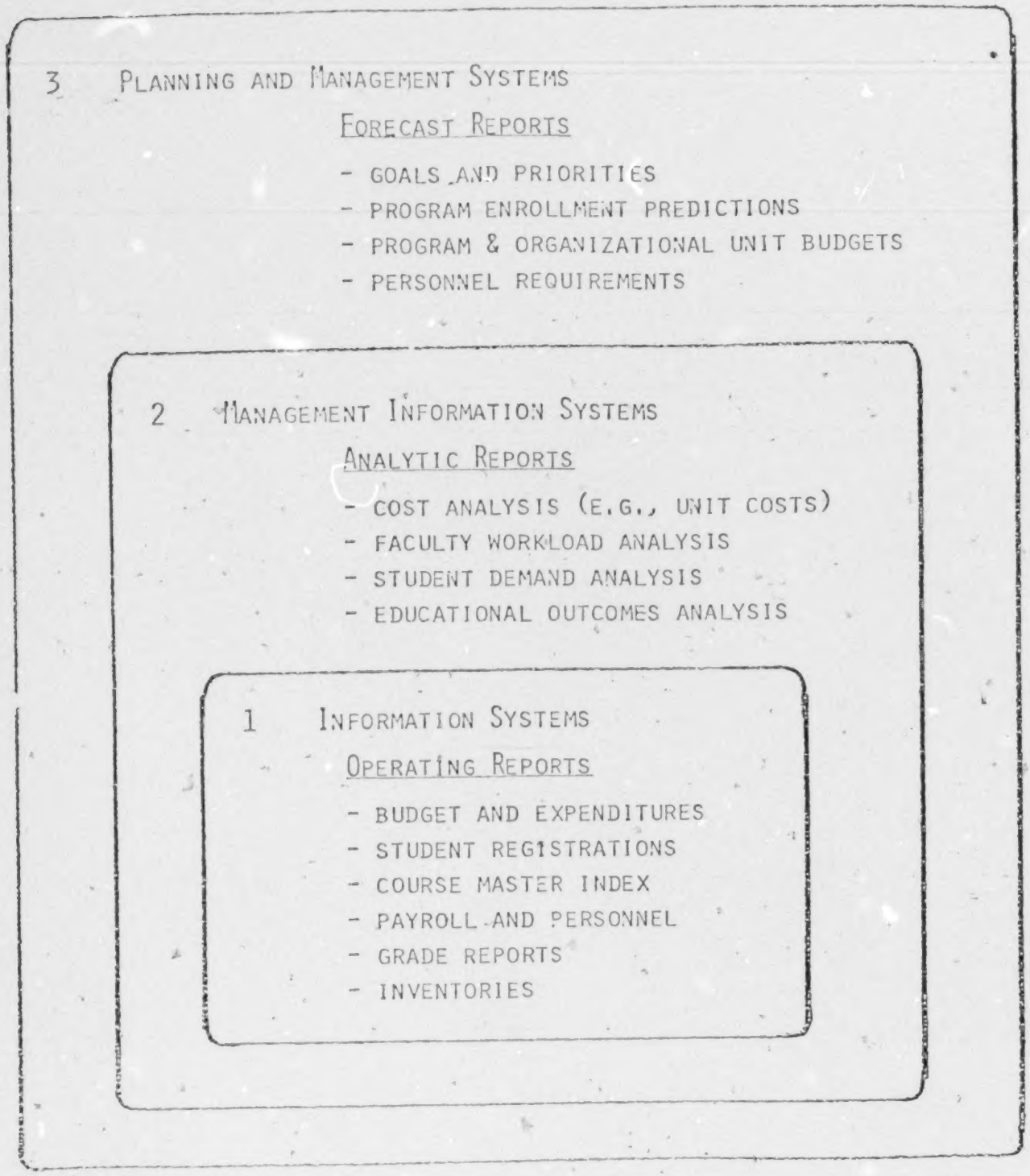


FIGURE 3
HIERARCHY OF INFORMATION SYSTEMS*



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